

EFFECTS OF FELL-AND-BURN SITE PREPARATION ON WILDLIFE HABITAT AND SMALL MAMMALS IN THE UPPER SOUTHEASTERN PIEDMONT

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Abstract—The fell-and-burn site preparation technique is an effective means of regenerating low-quality hardwood stands in the Southern Appalachian Mountains to more productive pine-hardwood mixtures. This technique offers a number of advantages over conversion to pine monoculture. These include: lower cost, increased vegetation diversity within the stand, improved aesthetics, and continued mast production. However, the technique has not been fully tested in the Piedmont and other regions. This study reports the early successional effects of several variations of the fell-and-burn technique on small mammal communities and wildlife habitat in the Upper Southeastern Piedmont. Burning was increased forage production and species richness of vegetation. Winter felling of residual stems was more effective than spring felling in stimulating forage production and increasing species richness of vegetation.

INTRODUCTION

The fell-and-burn site preparation technique has proven successful as an inexpensive means to regenerate low-quality stands to more productive pine-hardwood mixtures in the Southern Appalachian Mountains (Phillips and Abercrombie 1987). Complete descriptions of the technique are given by Abercrombie and Sims (1986), Phillips and Abercrombie (1987), and Van Lear and Waldrop (1988). Briefly, the technique involves a commercial clearcut followed by a spring felling of residual stems (> 2 m in height) and a summer broadcast burn, after which pines are planted on a 3 m by 3 m (10 by 10 feet) or wider spacing. It is anticipated that the technique will produce results in the Upper Southeastern Piedmont similar to those observed in the mountains.

However, differences in climate, soils, topography, and rainfall may make refinements to the technique necessary (Waldrop and others 1989). This method could become an attractive alternative to pine monoculture management for nonindustrial private forest landowners, who control approximately 80 percent of the commercial forested land in the Piedmont.

Benefits to wildlife have not been documented. However, it has been supposed that use of fell-and-burn methods would benefit certain game species, but there has been little consideration of effects on small mammals, insects, and herpetofauna in treated stands. For these reasons it is important to determine the effects of the technique on all components of the natural community before promoting its use in the Piedmont.

METHODS

Study Area

Study areas were located in the Upper Piedmont Plateau region of western South Carolina, on the Clemson University Experimental Forest in Pickens and Oconee Counties. Soils were sandy loams of the Cecil and Pacolet series. Annual temperature and precipitation average 15.5° C and 148 cm, respectively. During 1989, mean annual temperature was 0.8° C below normal, and mean annual precipitation was 23 cm above normal (NOAA 1989).

Prior to harvest, stand ages ranged from 45 to 55 years. Site indexes for shortleaf pine (*Pinus echinata* Mill.) at base age 50 years averaged 18 m (range 15 to 20 m). Stands consisted primarily of low-quality hardwoods dominated by upland oaks (*Quercus* spp.) and small numbers of shortleaf pine, loblolly pine (*P. taeda* L.), and Virginia pine (*P. virginia* Mill.). Basal area averaged 8.6 m²/ha. Aspects ranged from 180 to 230 degrees, and slope averaged 13.5 percent (range 10.0 to 20.0 percent).

Treatments

Each of three replications was divided into five 0.8 ha treatment areas. Each treatment area contained 5 to 7 sample plots, 0.1 ha in size. Treatments included clearcutting followed by winter-felling with and without summer burning; spring-felling with and without summer burning; and an unharvested control.

Habitat Analysis

Procedures for habitat analysis were modified from United States Fish and Wildlife Service Habitat Suitability Index (HSI) models (Mengak 1987, Mengak and others 1989, and Sanders 1985). Prior to the harvest, 10 to 20 0.04 ha vegetation plots were established along a transect within each treatment area. Plots were spaced at varying distances along the transect to best utilize the available area, avoid overlap, and maintain a southerly aspect. Permanent small-mammal

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trapping stations were also established at each plot center. Sampling was conducted during three sampling periods in 1989. Periods were chosen to evaluate the habitat at the lowest level of vegetation production (Jan. 1 to Mar. 31), the peak of production (May 1 to July 31), and the end of the growing season (Sept. 1 to Nov. 31). Ground cover estimates (by species) were obtained using a 35 mm ocular tube (James and Shugart 1970). Estimates were made at 1-m intervals along two 10-m transects within each sample plot. Transects were centered on the trap station.

Aboveground forage biomass was determined by clipping the current year's growth of all plants in a 1 m by 1 m plot randomly located within each 0.04-ha plot to a height of 1.5 m; forage was weighed in the field. Clipped material was separated into three categories: woody, forbs, and grasses. Moisture content of forage biomass was determined in the laboratory after drying in a forced-air oven at 60 degrees C° for 72 hours.

Trapping

Trapping took place during the three periods when vegetation was sampled. Traplines were prebaited with peanut butter for 5 nights with the traps closed and then sampling was conducted for 5 consecutive nights during each trapping period. Four trap types were used in each treatment area: Victor rat traps, Victor mouse traps, Museum special traps, and pitfalls with drift fences. All traps were rebaited each day during the prebaiting and trapping periods. Trapping design was identical for all periods.

One snap trap of each type was placed within 2 m of each randomly located trap station. Trapping stations were marked with 1-m sections of rebar in order to establish permanent trap locations. Pitfalls were randomly located on each site by overlaying a grid on the site map and using a random number table to determine their coordinates. A modification of the trap design described by Williams and Braun (1983) was used. Each drift fence consisted of three 5 m by 51 cm legs of aluminum flashing that met at a common point centered on the pitfall, with 120 degrees between each pair of legs. Flashing was set in a ditch 8 to 10 cm deep. These ditches were then packed with soil and the fences supported with wooden stakes. At the center of the fences, a 19-l plastic bucket was buried flush with the ground. Buckets were kept one-third to one-half full of water to drown captured animals, and were covered with a lid when not in use. All traps were checked daily during trapping periods.

Vegetation and trapping data were used to calculate Shannon diversity (H'), evenness (J), and species richness (S) for each trapping period. Shannon diversity was calculated as $H' = -\sum P_i (\ln P_i)$ where (P_i) is the proportion of the i th species in

the population (Shannon and Weaver 1949). This function measures the uncertainty in predicting the identity of any randomly selected individual based on the total number of species in the sample (S) and the number of individuals (N), or the proportion of that species to the whole sample (P_i) for each species represented in the sample. (J) is a measure of the evenness of the distribution of individuals within the species present, and is calculated as $J = H' / (\ln S)$ (Pielou, 1977).

Insects were collected in ten randomly located 600-ml pitfalls on each site. Traps were used for biomass collection, since terrestrial insects are more susceptible to capture in pitfalls, their numbers would be overestimated if individuals were singled out for identification (Southwood 1978). Traps were kept one-third to one-half full of equal parts of water and ethylene glycol, to keep the insects flexible. Traps were emptied daily during the 5-day period when small mammal trapping took place. All insects were identified to family and weighed for biomass.

All habitat and trapping data were summarized for each site and treatment type. Analysis of variance was used to test for differences between treatments, blocks, and collection periods. Differences were tested for significance at the 0.05 level.

RESULTS AND DISCUSSION

Vegetation

Biomass. Total forage biomass was greatest on winter-felled sites and on burned sites (Fig. 1). All treatments that included felling produced more forage biomass than the unharvested control plots. Total woody biomass, which was highly variable, did not differ significantly among treatments. Woody biomass production varied within the treatments depending on the species of woody vegetation present on the site. This variation within treatments masked any between-treatment differences that might have been developing. Forb production was greatest on burned sites, particularly with winter felling. This forb response resulted from removal of the litter layer which improved seed germination conditions. Grass production was significantly higher on the winter-felled no-burn sites than all other treatments as a result of sprouting from pre-existing rootstocks beneath the litter layer. The controls had significantly lower grass production than all other treatments as a result of the heavy litter layer and almost complete shading of the forest floor. Increases in grass and forb coverage at the expense of woody vegetation are common after burning and have been documented by (Langdon 1981, Waldrop and others 1987, Van Lear and Waldrop 1989).

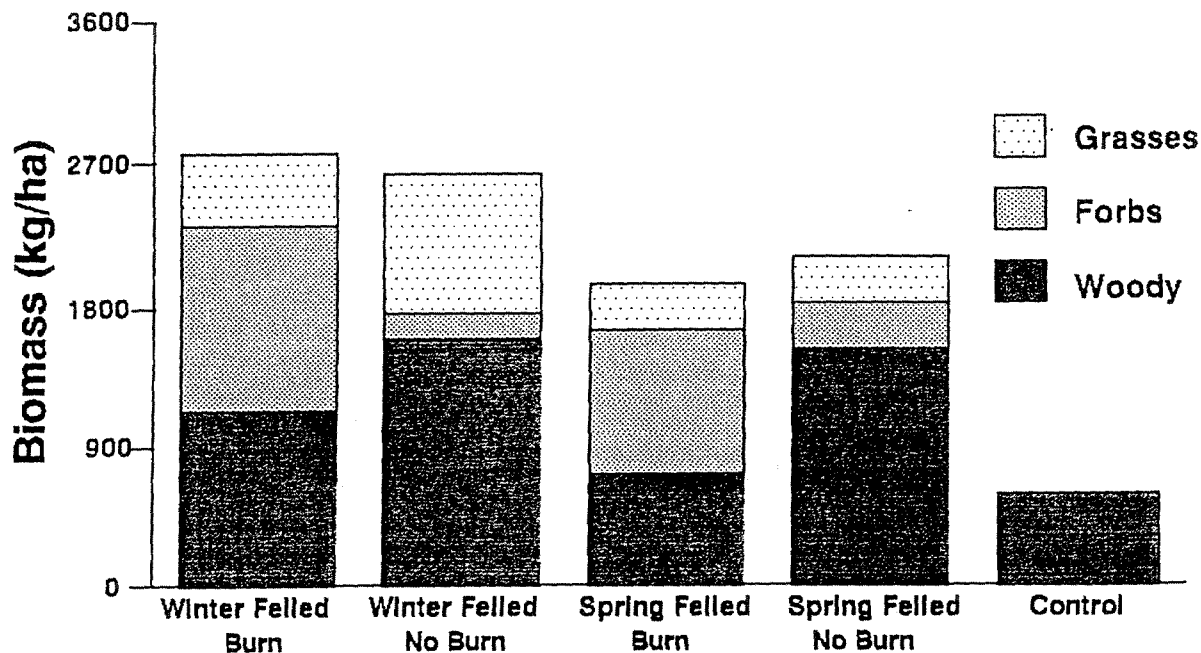


Figure 1. Forage biomass production by species group and treatment on fell-and-burn site-prepared areas in the Upper Southeastern Piedmont.

During the first sampling period after the burn, considerable browsing occurred on blackgum (*Nyssa sylvatica* Marsh.), American holly (*Ilex opaca* Ait.), sassafras (*Sassafras albidum* (Nutt.) Ness.), and smilax (*Smilax* spp.) seedlings and sprouts. During the second sampling period, utilization of the same species continued. Pokeweed (*Phytolacca americana* L.) however emerged as the most heavily browsed species. Pokeweed was often browsed to the point of being stunted. During the final sampling period, utilization of woody browse seemed to decline, probably due to the lignification of the woody tissue. While utilization of pokeweed and smilax remained steady. Because summer rainfall was higher than normal forbs on these sites remained succulent into October and November, when they would normally have hardened and been abandoned as preferred browse species.

Diversity, Richness, and Evenness. Diversity of vegetation (H') increased slightly as a result of winter felling, but there were no significant differences in H' between treatments. Species differences did occur among treatments as a result of burning, but these differences did not significantly affect H' . Burning favored grasses and forbs while unburned areas were dominated by sprouts of trees and shrubs.

Species richness of vegetation (S) was significantly higher on burned areas than in unburned areas and unharvested controls (fig. 2). Among the burning treatments, winter felling produced significantly greater species richness values³. Due to the absence of leaves on the slash, winter-felled sites typically did not burn as evenly or completely as spring-felled sites (Geisinger and others 1989). Therefore a mosaic of burned and unburned microsites was created, with each one capable of supporting a different complement of species.

Vegetative evenness (J) did not differ significantly among treatments. However, J was slightly higher on winter-felled no-burn sites due to increased grass production on those sites.

Small Mammals

Diversity, Richness, and Evenness. Diversity of small mammals (H') showed no significant differences among treatments until the third sampling period (Sept. 1 to Nov. 31) (table 1). At that time, small mammal abundance on all site-prepared areas declined with the winter decline of vegetative browse and ground cover. This pattern agrees with the finding of Briese and Smith (1974) that small mammals shift the centers of their ranges throughout the year to take advantage of the distributional change in food and cover. H' was greater on the unharvested controls than on the treated sites during the third period as a result of the fall mast crop and the greater cover afforded by the undisturbed little layer.

Species richness (S) values were low in the first sampling period and there were no significant differences in S among treatments (table 2). In the second sampling period, winter-felled, burned sites had significantly higher S values than other sites. However, in the third sampling period, species richness was significantly lower on winter-felled burned sites as a result of the early senescence of the forb species that dominated those sites. Both food and cover declined much earlier on winter-felled burned sites than on those where grasses or woody vegetation were more dominant. Evenness (J) values did not differ significantly among treatments in the period.

³See Evans (1990, unpublished thesis) for a full species listing.

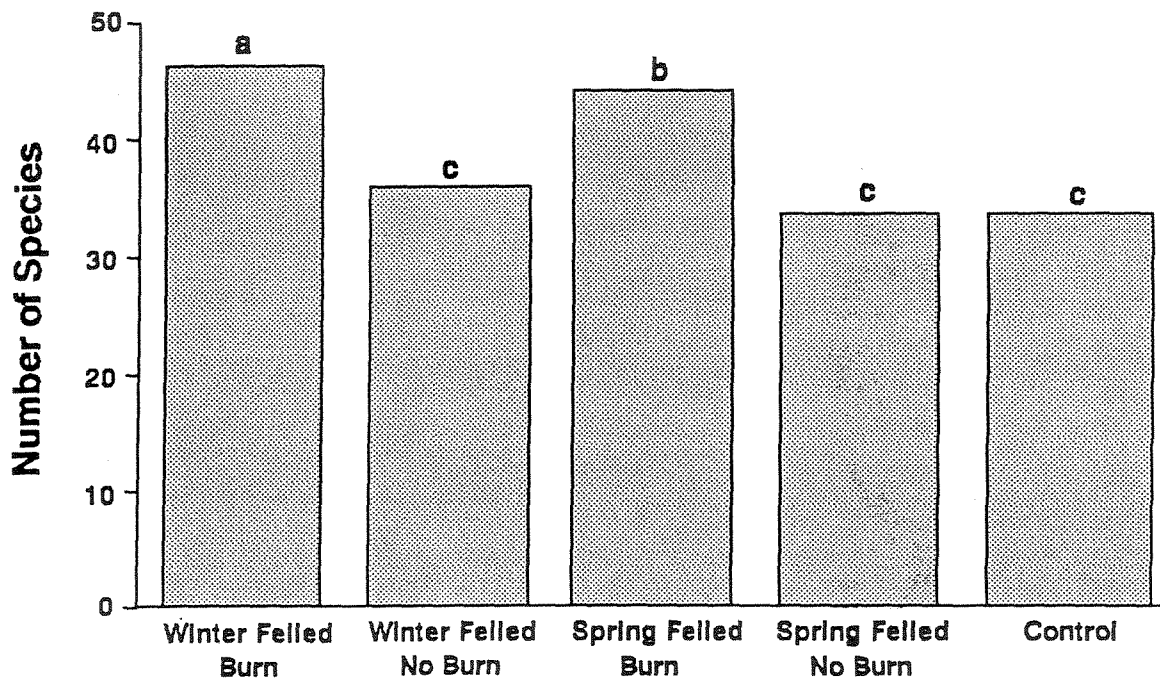


Figure 2. Plant species richness on felled-and-burn site-prepared areas in the Upper Southeastern Piedmont (columns with the same letter were not significantly different at the 0.05 level using Duncan's Multiple Range Test).

Table 1. Small-mammal diversity (H') on felled-and-burned study sites in the Upper Southeastern Piedmont, 1989.

Treatment	Period		
	Jan. 1-Mar. 31	May 1-July 31	Sept. 1-Nov. 31
Winter-Fell, Burn	0.0a	0.261a	0.092a
Winter-Fell, No-burn	0.1a	0.173a	0.360ab
Spring-Fell, Burn	0.0a	0.235a	0.409ab
Spring-Fell, No burn	0.0a	0.191a	0.192a
Control	0.0a	0.000a	0.519b

-Values followed by the same letter within a column were not significantly different at the 0.05 level using Duncan's Multiple Range Test.

Table 2. Species richness (S) of small mammals on felled-and-burned study sites in the Upper Southeastern Piedmont 1989.

Treatment	Period		
	Jan. 1-Mar. 31	May 1-July 31	Sept. 1-Nov. 31
Winter-Fell, Burn	0.333a	2.667a	1.333a
Winter-Fell, No-burn	1.333a	1.667ab	2.667ab
Spring-Fell, Burn	0.667a	2.000ab	3.333b
Spring-Fell, No burn	1.000a	2.000ab	2.000ab
Control	0.667a	0.333b	3.333b

-Values followed by the same letter within a column were not significantly different at the 0.05 level using Duncan's Multiple Range Test.

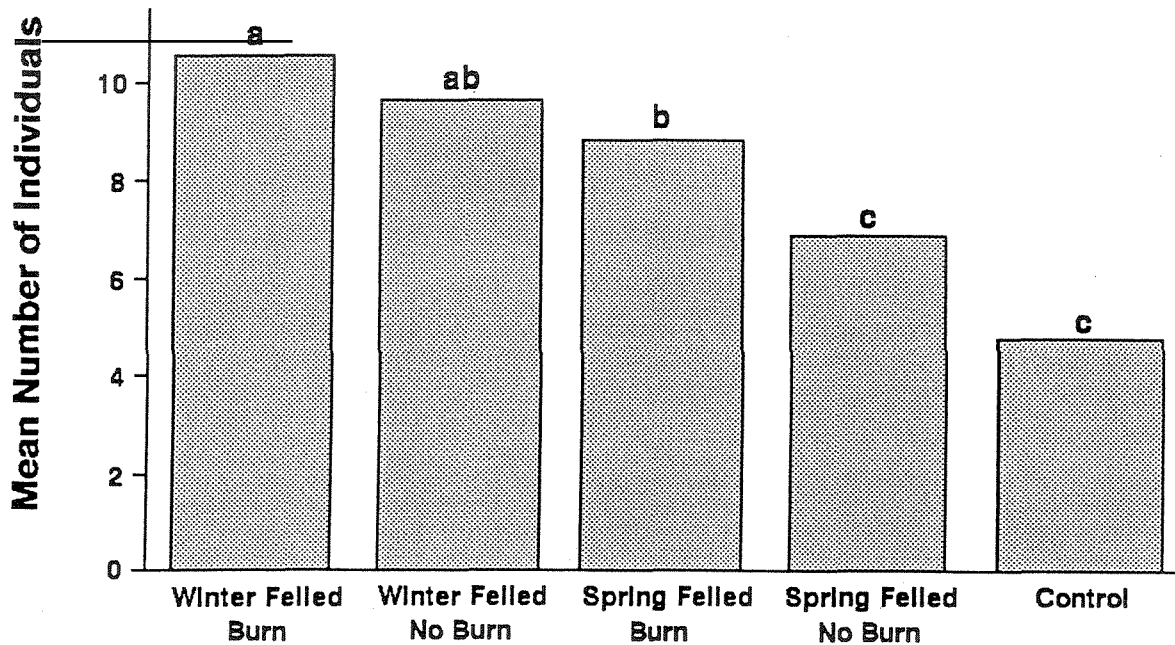


Figure 3. Number of individual small mammals on fell-and-burn site-prepared areas in the Upper Southeastern Piedmont (columns with the same letter were not significantly different at the 0.05 level).

Number of individuals. Both winter-felling and burning resulted in higher numbers of small mammals (N) utilizing an area (fig. 3). This increase is probably a response to the increase in available forage (vegetation biomass) that resulted from this treatment combination. Not all small mammal species increased in numbers in response to disturbance. Species that were trapped most often, such as white-footed mice (*Peromyscus leucopus*), were those that are best adapted to an early successional environment (table 3). This finding

agrees with a number of other studies that show an increase in *Peromyscus* spp. following fire (Ahlgren 1966; Kresting and Ahlgren 1974; Hingtgen and Clark 1984). The increase in *Peromyscus* spp. was most pronounced during the first two sampling periods and was no longer evident by the third sampling period. By that time the habitat was sufficiently developed to support a larger number of species with more varied food habits and cover requirements.

Table 3. Relative abundance and total number of individual animals (N) captured, by species, on all fell-and-burn study sites in the Upper Southeastern Piedmont 1989.

SPECIES		N	ABUNDANCE (PCT)
MAMMAL			
white-footed mouse	(<i>Peromyscus leucopus</i>)	97	63.8
golden mouse	(<i>Ochrotomys nuttallii</i>)	13	8.5
house mouse	(<i>Mus musculus</i>)	10	6.6
eastern cottontail rabbit	(<i>Sylvilagus floridanus</i>)	7	4.6
cotton rat	(<i>Sigmodon hispidus</i>)	6	3.9
cotton mouse	(<i>P. gossypinus</i>)	2	1.2
eastern chipmunk	(<i>Tamias striatus</i>)	1	0.7
least shrew	(<i>Cryptotis parva</i>)	1	0.7
southeastern shrew	(<i>Sorex longirostris</i>)	1	0.7
black rat	(<i>Rattus rattus</i>)	1	0.7
TOTAL=		139	91.4
BIRDS			
mourning dove,	(<i>Zenaida macroura</i>)	1	0.7
TOTAL=		1	0.7
HERPETOFAUNA			
American toad	(<i>Bufo americanus</i>)	3	2.0
Woodhouse's toad	(<i>B. woodhousei</i>)	2	1.2
eastern box turtle,	(<i>Terapene carolina</i>)	2	1.2
southern leopard frog	(<i>Rana sphenocephala</i>)	1	0.7
eastern narrow-mouthed toad	(<i>Gastrophyrne carolinensis</i>)	1	0.7
ring-necked snake	(<i>Diadophus punctatus</i>)	1	0.7
TOTAL=		10	6.5
OTHER			
brown grand-daddy longlegs,	(<i>Phalangium opilio</i>)	1	0.7
Carolina locust,	(<i>Dissostiera carolina</i>)	1	0.7
TOTAL=		2	1.4
GRAND TOTAL=		152	100.0

1-indicates an incidental capture in a snap trap

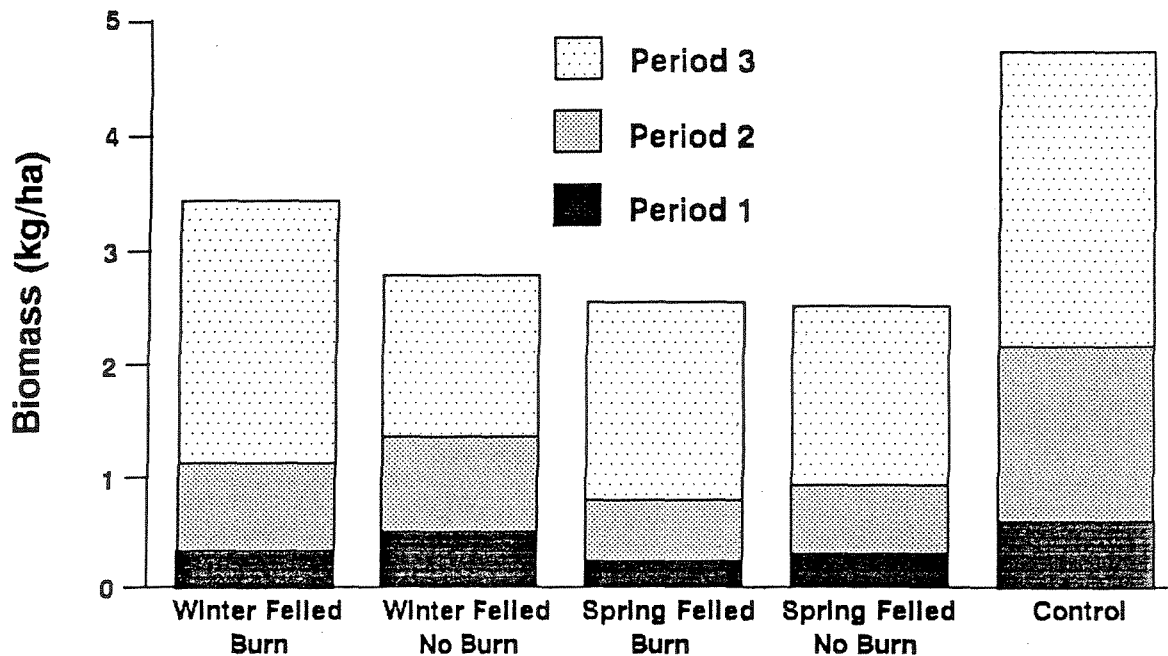


Figure 4. Insect biomass production on fell-and-burn site-prepared areas in the Upper Southeastern Piedmont, 1989.

Insects

Biomass. Total insect biomass was decreased temporarily by all site preparation treatments (fig. 4). Control sites averaged 4.7 kg/ha, while treated sites averaged 2.8 kg/ha. Insect biomass did not decrease as dramatically on winter-felled sites as on other sites, probably because fire intensities were lower on the winter-felled sites. Insect biomass was significantly higher on control sites than on other sites during the first sampling period. Both winter-felled and control sites were significantly higher than other sites during the second sampling period. Recovery of insect biomass production was rapid and there were no longer significant differences by the third sampling period.

SUMMARY AND CONCLUSIONS

Vegetation biomass production was greater for all site preparation treatments than for the control. Burned plots supported richer, more productive plant communities and higher numbers of small mammals than did unburned plots. Winter-felling and burning yielded richer, more productive plant communities and higher numbers of small mammals than spring felling and burning. As vegetation biomass production declined in the fall, small-mammal numbers became highly variable within treatments. Insect biomass production was reduced by all site preparation treatments due to disturbance of the litter layer. However, this decrease in production lasted less than 1 year.

This study indicates that the fell-and-burn site preparation technique, as it is practiced in the Southern Appalachian Mountains, can be used in the Upper Piedmont without adversely affecting forage production for wildlife habitat. If felling of residual stems is conducted in the spring, as is recommended in the Southern Appalachian Mountains, site preparation burns can significantly reduce fuel loads and provide uniform planting conditions (Sanders and Van Lear 1987; Geisinger and others 1989). Burns conducted after winter felling are less uniform (Geisinger and others 1989) and leave more of the slash and logs that provide cover and foraging sites for small mammals. More complete burns also result in a more homogenous habitat than the mosaic of burned and unburned microsites found on winter-felled areas.

The fell-and-burn technique is a relatively inexpensive method to regenerate pine-hardwood mixtures but its application in the Piedmont requires additional study. Effects on wildlife, water quality, and soil as well as on stand regeneration and development are currently being studied. As Van Lear and Kapeluck (1989) have shown, burning prescriptions on Piedmont sites must be modified if erosion is to be controlled. Species composition and soil characteristics of Piedmont sites are different from those of mountain sites, and it may be necessary to modify fell-and-burn techniques because of those differences. Finally, this study addressed only the early successional habitat changes that resulted from this technique. The impact of this type of site preparation on wildlife as the stands continue to develop is yet to be determined.

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